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Physico-Chemical Characteristics and Bacteriological Studies in Hand Dug Wells in Udu Community of Delta State, Nigeria

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Abstract
Sixty (60) water samples of hand-dug wells were collected from Udu community (delta state) and analysed physico-chemically and microbiologically using standard methods. The results of the physico-chemical analysis were obtained in the following range; pH (7.12 - 7.45), conductivity (78.38-397.55µScm^{-1}), turbidity (3.58-8.17NTU), DO(3.77-4.76mg/l), BOD_5 (1.49-1.75mg/l), bi-carbonate (2.77-27.97mg/l), chloride (16.37-58.27mg/l), nitrogen (0.002-0.01mg/l), calcium (1.79-7.22mg/l), magnesium (0.41-2.18mg/l), sulphate (0.13-1.78mg/l), nitrate (0.001-0.72mg/l) and phosphate (0.12-0.38mg/l). All the water samples were found to harbor coliform organisms in numbers greater than the required WHO/SON standards for drinking water; Presumptive coliform count ranged from 1.69×10^2 to 1.66×10^3cfu/ml; aerobic mesophillic count 2.82×10^2 to 1.50×10^3cfu/ml and *Escherichia Coli*; 1.35×10^1 to 2.19×10^2cfu/ml. High coliform count was recorded during the rainy season as compared to dry season of this research. However, regular monitoring as well as purification measures such as boiling and filtration is recommended before use to ensure a healthy living.
Keywords: hand-dug wells, water quality, physico-chemical parameter, bacterial analysis, WHO/SON.

INTRODUCTION

In recent times, there has been a paradigm shift from surface water usage to ground water due to factors such as accessibility and availability of groundwater in both dry and rainy seasons of the year, low cost maintenance, and low cost technologies. Various forms of ground water available to the Nigerian population are; hand-dug wells, drilled wells, driven wells and artesian wells (Tekwa *et al.,* 2006). Groundwater is simply water located beneath the ground surface in soil pore spaces and in the fractures of rock formations (Adeyeye and Abulude, 2004). It is about 20% of the world's fresh water supply, which is about 0.61% of the entire world's water, including oceans and permanent ice (Asadi *et al*., 2007). Groundwater can be a long-term 'reservoir' of the natural water cycle (with residence times from days to millennia), as opposed to short-term water reservoirs like the atmosphere and fresh surface water which have residence times from minutes to years (Cunningham and Cunningham, 2004).

Contamination of groundwater resources from sewage pits, septic tanks, oil wells and heavy metals has resulted in the degradation of some drinking water supplies. Therefore, the presence of contaminants in natural freshwater continues to be one of the most important environmental issues in many areas of the world. The physical, chemical and microbial characteristics of water are important parameters of concern, as they may directly or indirectly affect its quality (Lee and Song, 2007; Abowei, 2010). Evaluation of these parameters in ground water is of high priority due to changes in water chemistry caused by natural, domestic, industrial and agricultural discharges which may lead to deterioration of ground water quality. Communities which rely on untreated groundwater supply for domestic and agricultural uses are the most exposed to the impact of poor water quality (Agbabiaka and Sule, 2010; Akpoveta, *et. al.,* 2011). It is estimated that the number of people without access to safe drinking water is as high as 1.5billion with all the consequences for water borne diseases such as typhoid, cholera, diarrhoea and dysentery become potentially communicable (WHO, 2011). In view of this fact, water quality monitoring becomes essential for identifying problems and formulating measures to minimize deterioration of water quality. The objective of this research is to provide information on the physico-chemical and microbial characteristics of Udu hand-dug wells as well as to discuss its suitability for human consumption based on water quality standards.

MATERIALS AND METHODS

The study area.

Udu community is located in Udu Local Government Area of Delta State, Nigeria between latitudes 05°29′ 30.0″ to 05°30′30.1″ N and longitudes 05° 48′57.1″ to 05°51′41.2″ E (fig.1). The entire area is low-lying and is characterized by two major climatic seasons, a dry season spanning from November to March, and a wet or rainy season from April to October with a short break in mid-August. Total annual and mean precipitation is about 2674 mm and 223mm respectively. This is an additional source of groundwater recharge in the area while annual and mean relative humidity reads 840mm and 70mm respectively (Dept. of Meteorological Station, Warri). The major source of water in this area is the hand-dug well which is basically in use for a variety of domestic and industrial activities.

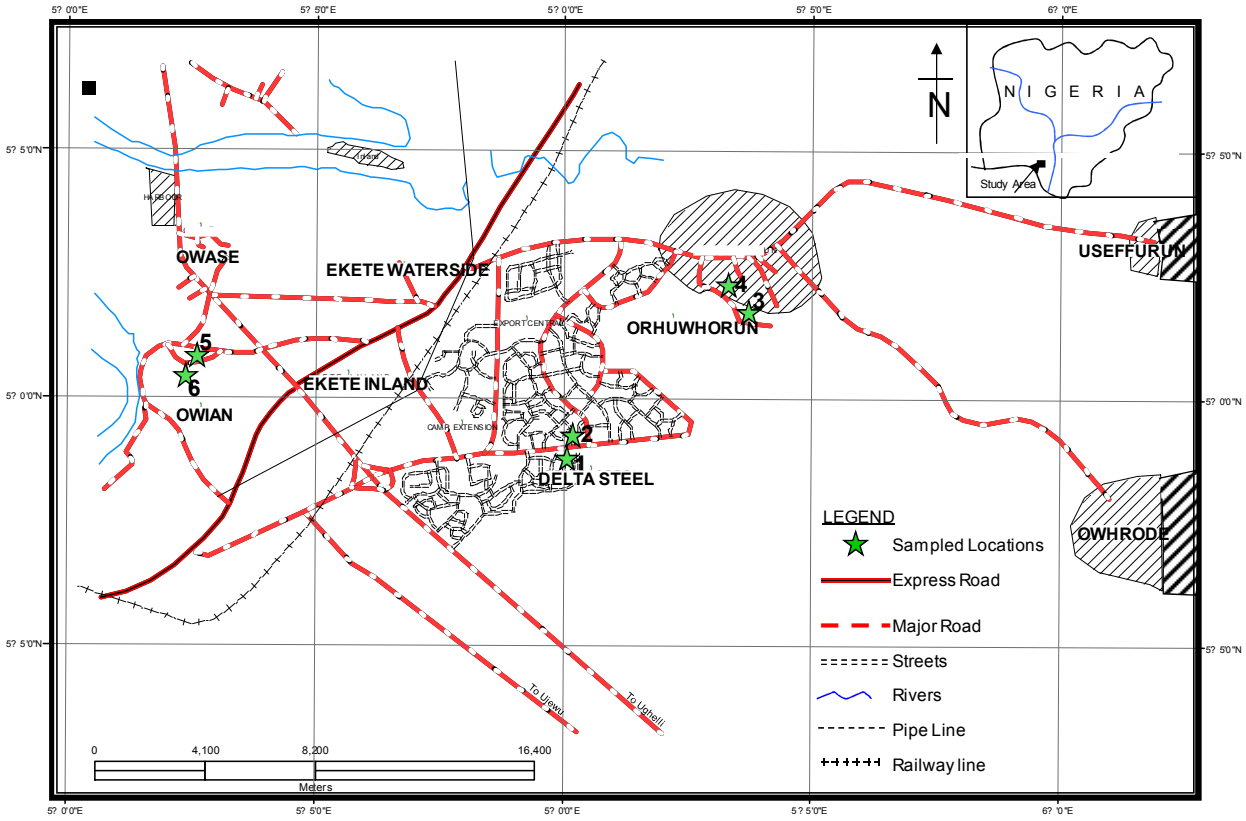

Fig. 1: Map of the Study Area

Sample collection and analysis

Water samples were taken from the six hand-dug wells at intervals of one month over a period of ten (10) months which included dry and wet seasons. The Physical and chemical parameters were analysed for 15 parameters: temperature, pH, turbidity, conductivity, total dissolved solids, dissolved oxygen, biochemical oxygen demand, total nitrogen, calcium, magnesium, sulphate, nitrate and phosphate using standard methods as described by APHA (1998). Parameters obtained were compared with the limits set up by the World Health Organization (WHO, 2011) and Standards Organisation of Nigeria (SON, 2007) for drinking water. Data collected were subjected to statistical analysis using Analysis of variance (ANOVA) to determine their variations at stations and seasons.

Bacteriological analysis

All media used for bacteriological analysis of water were weighed out and prepared according to the manufacturer's specification with respect to the given instructions and directions. Presumptive coliform was determined using MacConkey broth. Positive result was indicated by acid and gas production on incubation at 37^{o}C for 48 hours (Edema *et al.*, 2001). The aerobic mesophllic count was determined by pour plate technique using standard methods (APHA, 1998). Nutrient agar medium was used for the enumeration of bacteria in the samples. Eosin methylene blue agar was used to determine *E. coli* on incubation at 45^{o}C for 24hrs. Organisms with greenish metallic sheen were taken positive for *E. coli*.

RESULTS and DISCUSSION

The physico-chemical characteristic of water samples from the six hand-dug wells are as presented in tables 1. The quality in comparison to World Health Organisation (WHO, 2011) and Standard Organisation of Nigeria (SON, 2007) acceptable levels in the guidelines for water is reported.

Table 1: Summary of the Mean Physical and Chemical parameters of Hand-dug Wells.

PARAMETERS	Units	N	WELL 1 Mean ± S. E	WELL 2 Mean ± S. E	WELL 3 Mean ± S. E	WELL 4 Mean ± S. E	WELL 5 Mean ± S. E	WELL6 Mean ± S.E	WHO LIMIT	SON LIMIT
Air Temp.	^{O}C	10	28.37 ± 0.20	28.85 ± 0.24	28.7± 0.21	28.4 ± 0.16	28.75 ± 0.20	28.8 ± 0.25	-	-
Water Temp.	^{O}C	10	27.40 ± 0.26	27.40 ± 0.26	27.30 ± 0.23	26.80±0.21	27.25 ± 0.25	27.05 ± 0.26	-	-
pH		10	7.43 ± 0.36	7.12 ± 0.27	7.45 ± 0.21	7.43 ± 0.18	7.13 ± 0.30	7.12 ± 0.23	6.5-8.5	6.5-8.5
TDS	mg/l	10	38.05 ± 4.97	47.62 ± 9.90	47.35 ± 4.69	180.90±12.57	137.40 ± 19.18	155.85 ± 7.76	600	500
Cond.	µS/cm	10	78.38± 11.45	96.13 ± 20.42	88.98 ± 8.17	397.55±13.05	383.28 ± 58.80	313.78 ±17.08	1000	1000
Turbidity	NTU	10	3.58 ± 0.89	3.91 ± 0.78	8.17 ± 1.33	6.25 ± 1.10	4.61 ± 0.86	3.73 ± 0.91	5	5
DO	mg/l	10	4.25 ± 0.22	4.76 ± 0.31	3.77 ± 0.15	4.09 ± 0.15	4.15 ± 0.12	4.28 ± 0.16	>30	-
BOD_5	mg/l	10	1.75 ± 0.11	1.68 ± 0.14	1.49 ±0.13	1.56 ±0.10	1.70 ± 0.14	1.63 ± 0.15	>6.0	-
Chloride	mg/l	10	16.37 ± 2.55	19.01 ± 4.29	21.78 ±3.52	58.27 ± 4.36	45.61 ± 4.28	43.87 ± 4.84	250	250
HCO_3	mg/l	10	2.77 ± 0.16	4.00 ± 0.51	4.90 ± 0.29	27.97 ± 3.67	19.61 ± 2.44	16.06 ± 0.94	-	-
Total N_2	mg/l	10	0.005±0.002	0.004 ± 0.001	0.002 ±0.00	0.01±0.002	0.007 ± 0.002	0.005 ± 0.001	50	-
Calcium	mg/l	10	1.86 ± 0.37	1.79 ± 0.40	2.59 ± 0.68	3.52 ± 1.04	6.80 ± 1.23	7.22 ± 0.69	200-300	
Magnesium	mg/l	10	0.41± 0.09	0.9 ± 0.23	1.81 ± 0.32	2.03 ± 0.35	1.52 ± 0.48	2.18 ± 0.37		0.2
Sulphate	mg/l	10	0.354 ± 0.064	0.126 ± 0.099	0.314±0.088	1.778 ± 0.245	0.716 ± 0.247	1.277 ± 0.175	250	250
Nitrate	mg/l	10	0.001 ± 0.0	0.002 ± 0.0	0.240±0.127	0.045±0.017	0.716±0.247	0.043±0.009	-	50
Phosphate	mg/l	10	0.115±0.097	0.126±0.099	0.314±0.088	0.381±0.079	0.331±0.097	0.345±0.074	-	100

A clear pattern of seasonal variations was observed in the temperature values. High values were recorded in the dry seasons and low values in the rainy seasons of the year across the wells. However, air temperature and water temperature of the study wells ranged between 28-30^{o}C and 26-30^{o}C respectively. This was similar to the study of Olabaniyi and Owoyemi, 2004. pH showed a slightly alkaline trend irrespective of seasonal variation. The pH range of 7.12 - 7.45 recorded for the water sample could be considered as being within acceptable range for drinking waters (WHO, 2011).

All the water samples were low in BOD_5 (1.49-1.75mg/l) and DO (3.77-4.76mg/l) values. Lowest DO value (3.77mg/l) was recorded in well 3 which is located at a rural community farm beside a palm oil processing mill. The discharge of organic matter such as leaf fall, oil palm effluents, and eroded farm residues especially during high precipitation must have resulted to its low DO value. Electrical conductivity values were within the set limit by the World Health organisation as values between the wells were highly significant ($P<0.05$). High mean conductivity values (397.55mg/l, 383.28 mg/l and 313.78 mg/l) were recorded in well 4, 5 and 6 respectively. TDS values in all the wells ranged between 38.05-180.90mg/l. This was within the permissible limit for drinking water (500mg/l) WHO, 2011. The mean turbidity values (8.17NTU and 6.25NTU) in well 3 and 4 respectively, were high above the WHO/SON limits. This could be attributed to the presence of organic matter pollution and run-off with high suspended matter content into the wells. Nitrate was relatively low in the well water samples, as mean values ranged from 0.001 to 0.716mgl^{-1}. Nitrate is the most highly oxidized form of nitrogen compounds and is commonly present in groundwater because it is the end product of the aerobic decomposition of organic nitrogenous matter. However, Nitrate values in the wells were within the WHO set limits for drinking water and similar with works reported by Akujieze and Oteze (2006).

The Calcium ion (Ca^{2+}) and Magnesium ion (Mg^{2+}) contents were generally low in the wells and good for human consumption. Values ranged from 1.79 to 7.22mg/l for calcium and 0.41 to 2.18mg/l for magnesium. Sulphates naturally occur in groundwater by the dissolution of sulphides such as pyrite from the interstratified materials by percolating water producing sulphate ions **(**Olobaniyi, and Owoyemi, 2006**).** This study revealed a low mean sulphate values in the wells ranging from 0.126 to 1.778mgl^{-1} which is within the WHO/SON tolerable limits of 500 mgl^{-1}. The low concentration of sulphate could be attributed to the absence of anthropogenic factors such as vehicular activities and petroleum refining process in the location of the wells. Chloride is a widely distributed element in all types of rocks in one or the other form (Braide *et al*., 2004). Its content in the well was found to be within the permissible limits for drinking water (250 mg l^{-1}), chloride contents range from 16.37 to 58.2mg l^{-1}.

One way analysis of variance of physico-chemical parameters revealed that TDS, conductivity, turbidity, DO, chloride, bi-carbonate, total nitrogen, calcium, magnesium, sulphate and nitrate showed a significant difference at $P<0.05$. On the contrary, water temperature, pH, BOD_5 and phosphate showed a non-significant difference at $P>0.05$. Statistically, the degree of linear association between any two of the water quality parameters was also determined by simple correlation coefficient. Significant positive correlations were observed between total dissolved solids and conductivity ($r=0.968$) as well as turbidity ($r= 0.754$). An increase in groundwater temperature showed a decreasing trend in conductivity, turbidity and total dissolved solids with correlation coefficient values of $r = -0.824$, -0.860 and -0.921 respectively. The nutrients, sulphates, and phosphates were positively significant when correlated with chloride, bicarbonates, calcium and magnesium while nitrate showed a non-significant interdependency to chloride and bicarbonates. This implies that the same source could be inferred for these elements that were significantly correlated (Egereonu and Nwanchukwu, 2005).

Table 2: Mean Summary of Bacteriological assessment of water samples in Hand dug well.

Parameter	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	WHO LIMIT
Aerob. Meso. Count(cfu/ml)	$1.50x10^3$	$6.85x10^2$	$3.80x10^2$	$4.74x10^2$	$2.82x\ 10^2$	$3.50x10^2$	10
Presumptive Coliform(cfu/ml)	$1.66x10^3$	$5.76x10^2$	$2.63x10^2$	$2.39x10^2$	$1.69x10^2$	$3.14x10^2$	0
E.coli (cfu/ml)	$2.30x10^1$	$1.35x10^1$	$7.05x10^1$	$2.19x10^2$	$4.54x10^1$	$4.20x10^2$	0

All the well water samples had the presence of bacterial counts which were probably from environmental sources. This was beyond WHO/SON allowable limits. The occurrence of the bacterial counts is shown in table 2. The mean values of Aerobic mesophilic count vary from 2.82×10^2cfu/ml to 1.50×10^3cfu/ml with a significance difference at $P<0.05$. *A posteriori* DMR test revealed that well 1 was significantly higher than other wells. This high bacterial count could be attributed to the close location of well 1 to a sewage pit which must have created an influx of bacteria in the well. The mean values of presumptive coliform count vary from 1.69×10^2cfu/ml to 1.66×10^3cfu/ml. A significance difference ($P<0.05$) was observed. *A posteriori* DMR test also revealed that well 1 was the cause of the significance difference. The mean values of faecal coliform revealing *E.coli* vary from 1.35×10^1cfu/ml to 2.19×10^2cfu/ml. Temporal variations showed that values were minimal, however high values were recorded in the rainy season between August and September. There was a significance difference ($P<0.05$) in the values obtained for *E.coli* in the wells. *A posterior* DMR test revealed that well 4 was significantly higher than other wells. This could be ascribed to the bad sanitary conditions of the well as well as populace inhabiting this location. Generally, the occurrence of high coliform populations in all the water samples is an indication of poor sanitary conditions in the community.

CONCLUSION

This study reveals that physico-chemical parameters appear to be within the set limits of WHO/SON. On the contrary, bacteriological assessment reveals that all the hand-dug wells were not free of coliform bacteria. However, continuous monitoring as well as water treatment measures is highly recommended for the population of Udu community before consumption of the well water to ensure maximum safety and a healthy living for all.

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